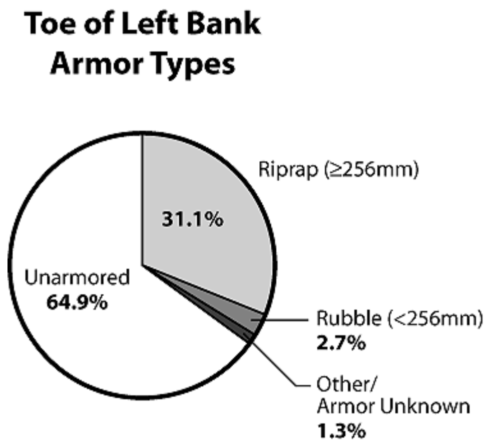

Figure 12.

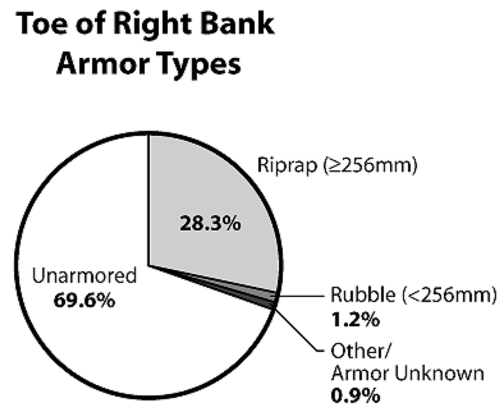

Figure 13.

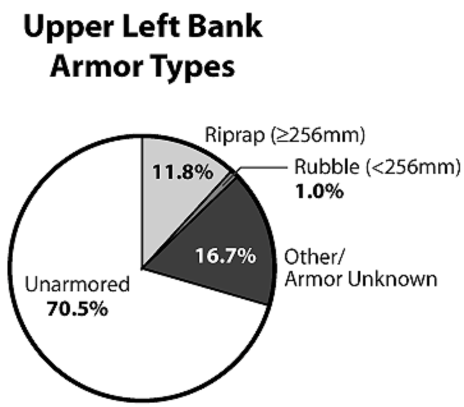

Figure 14.

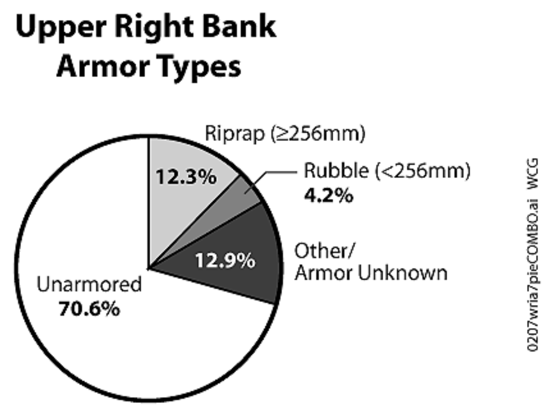

Figure 15.

By disconnecting the main channel of the river from its side channels and inhibiting natural channel migration, bank hardening in the study area limits the creation of summer rearing habitat and winter refuge habitat for salmonids and restricts fish access to off-channel habitat. Other adverse impacts of bank hardening are reducing or eliminating riparian cover, reducing LWD recruitment, eliminating undercut banks and thereby reducing gravel recruitment due to natural bank erosion, and altering the physical characteristics of width, depth, velocity, slope, and roughness within the main channel of the river.

The *Salmonid Species Habitat Conditions Review* (Snohomish Basin Salmonid Recovery Technical Committee, 2002) rates the Snoqualmie River mainstem as "degraded" for shoreline condition and floodplain connectivity because bank hardening affects more than 20% of shorelines (NOAA, 1996). In the summer of 2000, there was bank hardening on 35.1% of river miles on the toe of the left bank (LB—the bank on the left side of the river when looking downstream) and on 29.5% of river miles on the upper LB. There was bank hardening on 30.4% of river miles on the toe of the right bank (RB—the bank on the right side of the river when looking downstream) and on 29.4% of river miles on the upper RB. Riprap was found more frequently than rubble on both banks (Figures 6 to 15). The bank hardening percentages may actually be higher because some bank hardening is covered in silt and partially vegetated and therefore would not have been visible from the river during the habitat conditions inventory. Nevertheless, it remains effective hardening because it arrests channel migration and natural bank erosion critical for forming and rejuvenating habitat (Anderson, 2002).

Figures 6 to 11 also show the location and type of erosional features (i.e., scours and slumps) on the riverbanks. The erosional features shown on the maps were areas of active bank erosion below the ordinary high water mark (OHWM). Scour is the cumulative result of individual grains of sediment being plucked from a river channel by the force of flowing water. Scour can affect the bed or bank of the river and often occurs where natural or artificial irregularities (e.g., logs, boulders, bridge piers) cause local flow acceleration. Slumps are landslides (sliding of a continuous block of soil) that may occur partly or entirely under water. They are often triggered by scour at the toe of the riverbank, or by saturation of the bank by high flows or heavy groundwater seepage.

Scours and slumps are natural, important elements of aquatic ecosystems and contribute spawning gravel and nutrients to rivers and streams. However, excessive bank erosion can degrade habitat conditions by contributing excessive fine sediment, aggrading the channel bed, or filling pools. Bank erosion is accelerated by adjacent bank armoring such as riprap and by altered hydrologic regimes.

The *Salmonid Species Habitat Conditions Review* (Snohomish Basin Salmonid Recovery Technical Committee, 2002) rates the Snoqualmie River mainstem as “moderately degraded” for sediment regime (NOAA, 1996) because there was 10% to 20% actively eroding bank in the summer of 2000. Overall, active bank erosion was observed on 11% of the riverbanks in the study area. As might be expected, erosion was observed in areas where the banks were unarmored and was not observed in areas where revetments were present. However, by deflecting water away from a bank, armoring can lead to erosion issues at the next unarmored site downstream and/or across the river from the armored bank. This pattern was observed at many locations throughout the study area. For example, the RB is armored between RM 35.8-36.4 and is eroded downstream at RM 35.5. The LB is armored at RM 8.0 and is eroded directly downstream of the armoring. The RB is armored between RM 21.4-22.1 and is eroded on the LB at approximately RM 21.5. Similarly, the LB is armored between RM 9.3-9.6 and is eroded across the river on the RB at approximately RM 9.5.

<u>Access Points</u>

Figures 16 and 17 show the location of cattle, human, boat, and other vehicle access to the Snoqualmie River. There was a correlation between riverbank erosion and human or cattle access to the river. For example, bank slumping was observed immediately downstream of RM 7 and RM 8, and between RM 9-10 at locations where people could easily walk down the banks to the river. Bank scouring was observed between RM 9-10 and at RM 25.3, again at locations where people could access the river.

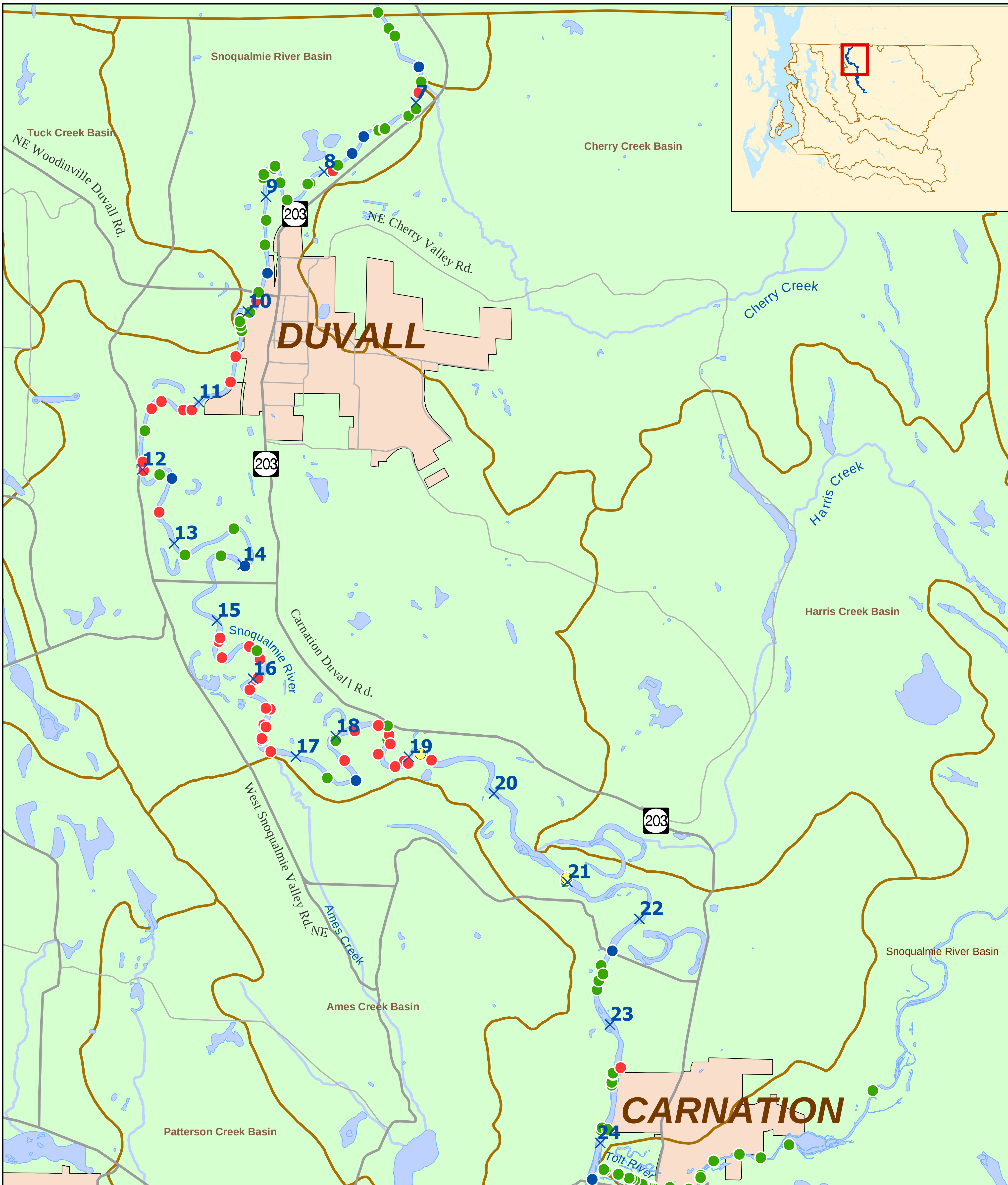

Figure 16.

SNOQUALMIE RIVER SURVEY: Access Points

Map 1 of 2

N

21 River Miles
Minor Roads
Major Roads
DNRP Basin Boundary
Incorporated Areas

CATTLE
HUMAN - BOAT
HUMAN - FOOT
VEHICLE

0 0.5 1 2 3 4 Miles

King County
Department of Natural Resources and Parks
Water and Land Resources Division

DATA SOURCE NOTES:
Erosional Features: KC DNRP & Washington Trout survey, 2000
Waterbodies: KC DNRP & WA DOE Hydrography Project, 1997
River Miles: Generated from waterbody routes in waterbody layer
Basin Boundaries: KC DNRP Basin Planning, 1997

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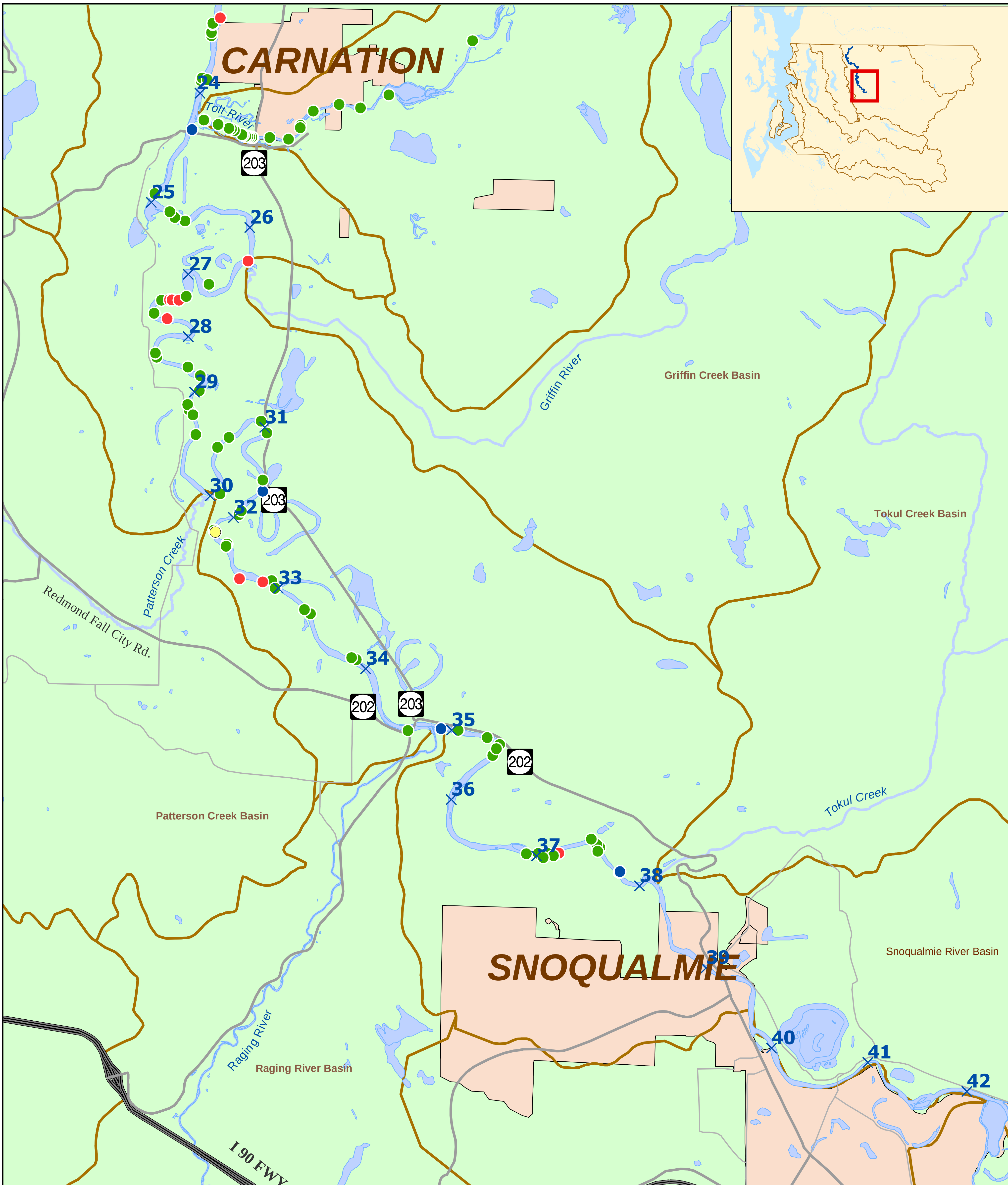

Figure 17.

SNOQUALMIE RIVER SURVEY: Access Points

Map 2 of 2

N

21 River Miles
Minor Roads
Major Roads
DNRP Basin Boundary
Incorporated Areas

CATTLE
HUMAN - BOAT
HUMAN - FOOT
VEHICLE

0 0.5 1 2 3 4 Miles

King County
Department of Natural Resources and Parks
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Although there were locations throughout the study area where cattle could access the river, most of the cattle access points were concentrated in the Agricultural Production District (APD) between the City of Duvall and the Harris Creek confluence (RM 10-19). Erosional features and cattle access coincided at RM 10.5, 12, 12.5, 16.5, 16.7, 17.7, and 19. Cows were observed grazing on top of the riverbanks at some locations and wading in the river at others. Horses were occasionally observed as well. For example, on August 31, 2000, the field team counted 17 cows and calves and one bull on the riverbanks, in the river, and on a gravel bar in one area between RM 16.5-16.7.

In addition to causing excessive erosion of riverbanks, loss of riparian vegetation, and destruction of riparian habitat, cattle access to the Snoqualmie River can contribute to nonpoint pollutant loading, especially nutrients (nitrogen and phosphorus) and fecal coliform bacteria. High levels of nutrients can degrade habitat conditions for salmonids and other aquatic biota by reducing DO levels in a waterbody or promoting excessive plant growth that can also reduce DO levels. It is not definitively known if high fecal coliform bacteria counts are a threat for fish, but high counts are a public health threat. Nutrient levels have been elevated, and fecal coliform bacteria counts have violated State of Washington water quality standards in the Snoqualmie River in the past (Fricke, 1995; Joy, 1994; Ehinger, 1993; Joy et al., 1991; Thornburgh et al., 1991). These water quality problems contributed to a rating of “degraded” water quality for the Snoqualmie River mainstem in the *Salmonid Species Habitat Conditions Review* (Snohomish Basin Salmonid Recovery Technical Committee, 2002).

Floodplain Features

Figures 18 and 19 show the location of floodplain features including the mouths of major tributaries (e.g., Cherry Creek, Harris Creek, and Griffin Creek) and small, unnamed tributaries as well as back channels, water diversion pumps, culverts, and flap gates. A flap gate is a flexible (normally hinged) covering of the outlet of a culvert designed to block high water from entering flood prone areas behind dikes and to allow drainage of water into a river’s main channel during normal, nonflood conditions.

Forty-six small, unnamed tributaries and 26 back channels were observed. Tributaries and back channels can provide good edge habitat for summer rearing and winter refuge for salmonids. These valley floor habitat features as well as wetlands and oxbows will be inventoried for habitat conditions and fish use in the summer of 2003.

Most of the water diversion pumps (10 out of 15) were located in the reach between the King-Snohomish County line and the City of Duvall (RM 6-10). The land in this reach is in the APD. It is likely that water is being withdrawn from the Snoqualmie River for irrigating crops and for drinking water for cattle. However, no assessment of diversions was made.

Eight flap gates and 15 culverts were observed throughout the study area. Water diversion pumps, flap gates, and culverts, especially perched culverts, can be barriers to fish habitat. These barriers can adversely affect juvenile and adult salmonids by eliminating or restricting access to upstream rearing and spawning habitat. Fish passage barriers can also cause reduced flow to downstream areas, thereby exacerbating passage problems, reducing the amount of refuge habitat, and decreasing the area and quality of food production for juveniles. Fish passage barriers restrict access to off-channel refuge habitat during high flow events as well (Snohomish Basin Salmonid Recovery Technical Committee, 2002).

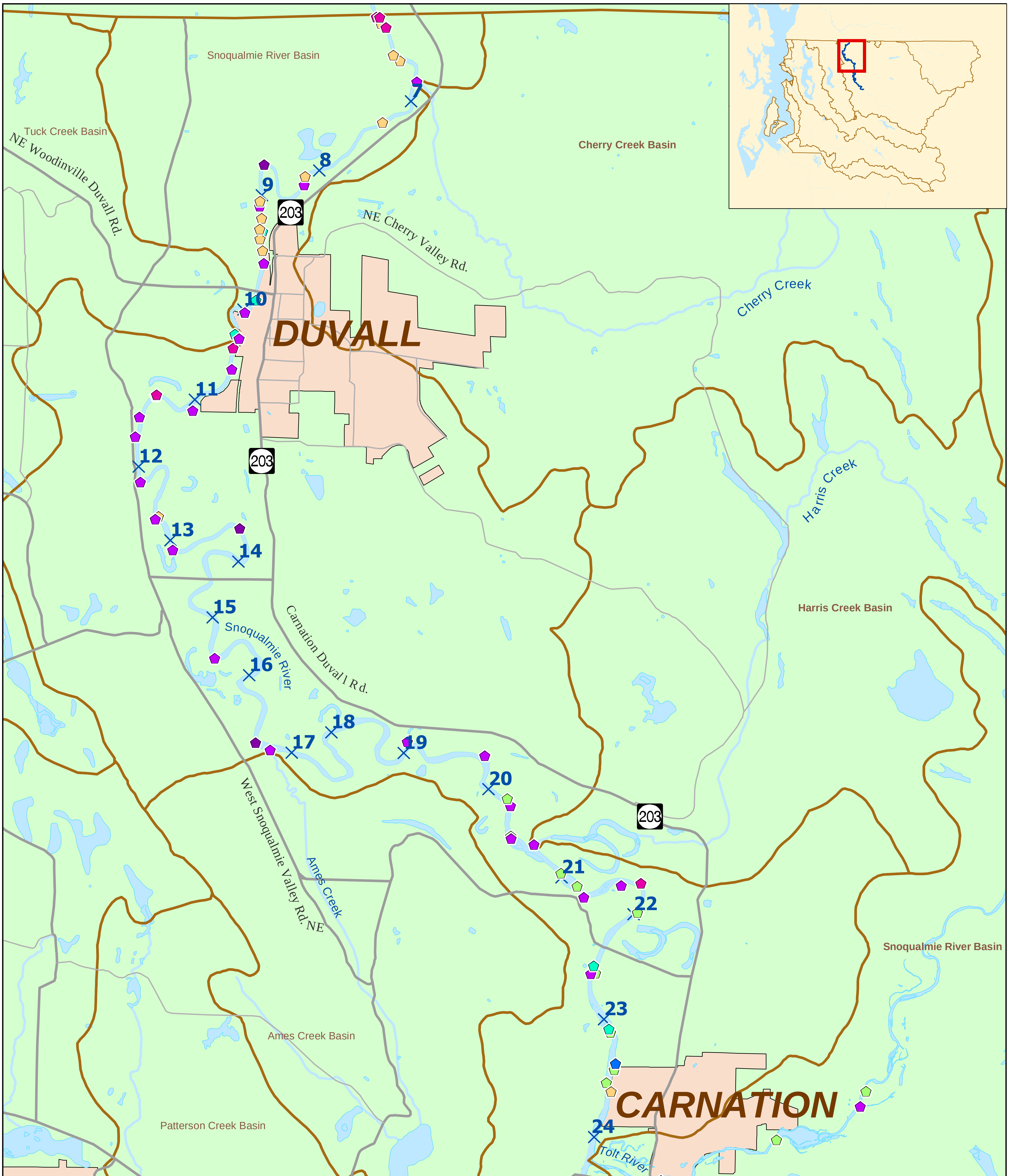

Figure 18.

SNOQUALMIE RIVER SURVEY: Floodplain Features

Map 1 of 2

N

21 River Miles
Minor Roads
Major Roads
DNRP Basin Boundary
Incorporated Areas

DIVERSIONS (PUMP)
FLAP GATE
BACK CHANNEL
MOUTH OF TRIBUTARY
OTHER
PERCHED CULVERT
SUBMERGED CULVERT

0 0.5 1 2 3 4 Miles

King County
Department of Natural Resources and Parks
Water and Land Resources Division

DATA SOURCE NOTES:
Erosional Features: KC DNRP & Washington Trout survey, 2000
Waterbodies: KC DNRP & WA DOE Hydrography Project, 1997
River Miles: Generated from waterbody routes in waterbody layer
Basin Boundaries: KC DNRP Basin Planning, 1997

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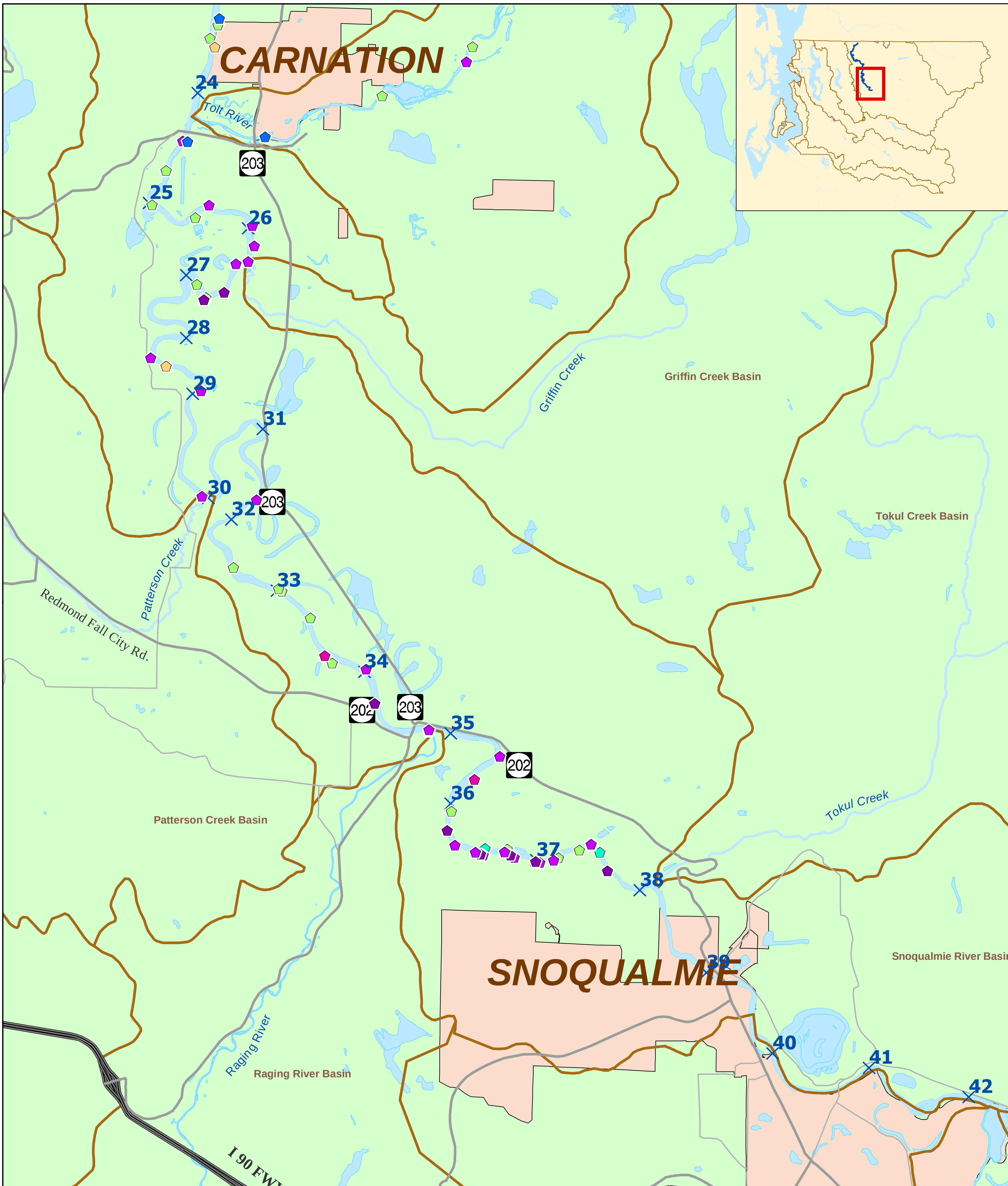

Figure 19.

SNOQUALMIE RIVER SURVEY: Floodplain Features

Map 2 of 2

N

21 River Miles
Minor Roads
Major Roads
DNRP Basin Boundary
Incorporated Areas

DIVERSIONS (PUMP)
FLAP GATE
BACK CHANNEL
MOUTH OF TRIBUTARY
OTHER
PERCHED CULVERT
SUBMERGED CULVERT

0 0.5 1 2 3 4 Miles

King County
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